

Plan Deconfliction, Repair, and Authoring in EDSS

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LONG-TERM GOALS

Our goal is to provide 6.2 extensions of the Expeditionary Warfare Decision Support System (EDSS), a GCCS-M prototype segment for authoring and simulating amphibious mission plans (e.g., ship-to-shore missions). Planners iteratively/manually adapt these plans (as needed). Although sophisticated, EDSS does not support “intelligent” plan authoring processes. In particular, it does not (1) automatically detect plan constraint violations, (2) proactively help the planner during plan revision (e.g., in response to plan execution failures), nor (3) share/reuse experiences from previously planned missions to assist with plan creation. During the course of this project, we will research and develop EDSS modules that support these capabilities. Our modules target and will be tested in the context of EDSS 2.x, where the primary metrics will include plan authoring time, number of plan-revision iterations, and some plan execution MOEs (as appropriate). Our project is an Accelerated Amphibious Mission Planning (AAMP) project funded by ONR (PM: B.Blumenthal, Code 32CM).

OBJECTIVES

We are pursuing the following objectives in this project:

1. *Automatic detection of plan constraint violations*: Amphibious mission planners must consider many constraints during the planning process, and the current EDSS implementation does not make these constraints explicit, nor test for their violation. In developing a constraint violation detection module, our goal is to define and implement a process for constraint representation, detection, and reporting. This first objective is purely technical.
2. *Mixed-initiative support for plan revision*: After identifying constraint violations, steps must be taken to eliminate them by revising the plan scenario. Our goal is to develop and implement a process for supporting user activities during plan revision. This includes identifying expected impacts of the violated constraint, searching and comparing COA alternative in the context of mission objectives, and sharing previous planning knowledge for eliminating the detected constraint violation. This objective has significant scientific merit; in addition to searching for alternative COAs, it will involve ranking them (i.e., plan recommendation). Although many researchers have studied recommendation systems for various tasks (e.g., for product selection), few have focused on *plan* recommendation (Luxenberg & Aha, 2002).

3. *Mixed-initiative support for plan authoring*: Rather than noticing plan constraint violations using an ad hoc process, these violations should be prevented from ever occurring by empowering the planner with a “smart” plan authoring tool. Our goal is to develop this tool, which will notify the planner of a probable constraint violation as soon as the planner defines the relevant plan scenario components that will yield this violation. This task has scientific merit, as it requires integration with EDSS’s simulator for non-visual testing of mission plans, retrieval and analysis of plans that have caused “similar” constraint violations (and their subsequent repair), and generation of alternative recommended plans that abide by mission operation objectives.
4. *Plan expertise sharing*: We want to provide EDSS planners with access to critical information from stored planning episodes for adaptation and reuse in subsequent planning episodes. This requires capturing mission plans (with their associated initial states, objectives, and MOEs), efficiently indexing/storing them, a fast retrieval algorithm that allows planners to analyze potentially relevant alternative plans, and an adaptation mechanism for plan revision. In addition, lessons can be learned concerning planning decisions that could be used to explain preferences for planning alternatives, and thus positively impact the planning process (Aha *et al.*, 2001). This task has significant scientific merit, as it involves extending the state-of-the-art in case-based planning methodologies.

APPROACH

Our primary project interactions have been with Shawn Faust, lead EDSS software engineer for SAIC, and Glenn Palmer, a Senior EDSS Analyst for SAIC who is stationed at COMPHIBGRU TWO. Glenn is serving as our domain expert and military liaison. All four tasks will involve EDSS task analyses, which are being performed in a sibling AAMP UW/NRL project. We intend to discuss these tasks analyses with NRL POC Jim Ballas, and build on their interface design efforts.

Task 1: *Automatic detection of plan constraint violations* (PD module). (FY02-03)

- 1.1 Domain familiarization: We have obtained and reviewed relevant background documents, listed in the References, on EDSS and ship-to-shore planning. We have also interacted with both Shawn and Glenn, primarily to identify constraint violations that should be prevented. This has lead to the identification of initial sets of constraints and their violations. In the near future, we will also visit with EDSS users (i.e., COMPHIBGRU TWO planners) to improve our understanding of the ship-to-shore planning domain and their use and expectations of EDSS. Table 1 describes some domain factors and their associated constraints.
- 1.2 Hardware acquisition: We obtained, using Shawn’s specifications, an HP 712/100 running HP-UX 10.20, which includes a 1-year service support license. This HP machine is running standalone to prevent unwarranted access to this sensitive software.
- 1.3 Software acquisition and familiarization: After Task 1.2, Shawn installed GCCS-M and EDSS v1.1. We then helped him to define an EDSS v1.2 component that outputs time-stamped (1 per minute) simulation data, which we input to our PD module. Glenn provided us with two example ship-to-shore planning missions (UNCLASS). Subsequently, a third was obtained from Shawn that SAIC uses to demonstrate EDSS. It was designed for EDSS v1.1; we modified it for v1.2. We used this software to familiarize ourselves with the EDSS computing environment.

Table 1: Factors of interest for constraint violation detection. [Includes ship proximity, air proximity, (LCAC/LCU) displacement, and visibility factors/constraints.]

Ship Proximity	Location Angle	Front (315°-45°): 1000yds Side (45°-315° & (225°-315°): 500yds Astern (135°-225°): 300yds
Air Proximity	Fixed/Fixed	1000ft min between each vehicle
	Rotary/Rotary	500ft min between each vehicle
	Fixed/Rotary	1000ft min between each vehicle
Displacement	Time	<i>N</i> minutes min between final AAV to reach beach and first LCAC/LCU crosses boat lane's LOD
	Distance	500yds min between LCAC & conventional lanes
		500yds min between any LCAC/LCU and any other LCAC/LCU
Visibility	Night/Day	Double all proximity constraint distances in night situations
	Fog/Clear	Double all proximity constraint distances in foggy situations

1.4 Module development: We have developed an v1.1 of the *Plan Deconfliction* (PD) module, in Java 2, based on repeated discussions with Glenn and Shawn concerning subject matter information concerning the constraint violations and preferences for integration with EDSS 2.x. We will be guided by the PM and other project members concerning the evaluation of PD (and our other modules) in future FBEs and other opportunities for experimentation.

Task 2: Mixed-initiative support for plan revision (PR module). (FY03)

- 2.1 Constraint violation impact assessment. We will integrate EDSS's simulator, in a non-visual mode to support fast execution, with the our FY03 Plan Revision (PR) module so that PR can predict and provide information on constraint violations. The user will have the option to ignore the constraint violation (e.g., due to additional knowledge concerning the violation).
- 2.2 Contingency plan generation. PR will be designed to generate alternative plans that eliminate the detected constraint violation(s) thru the minimal modification of EDSS plan scenarios. A first version of this will use only modeling information, while later versions will be able to base recommendations on the modifications of previous plans (see Tasks 3 and 4). We anticipate working closely with our subcontractor at the University of Maryland (POC: Prof. Dana Nau) on viewing plan revision as a dynamic planning task, and in incorporating their ideas into PR.
- 2.3 Module development. Similar to Task 1.4, with the addition of an interactive interface.

Task 3: Mixed-initiative support for plan authoring (PA module). (FY04)

- 3.1 Define hierarchical plan representation. We anticipate that our work with HICAP (Aha et al., 2001), and in particular its hierarchical representation of doctrine and plans, will suffice to model ship-to-shore mission planning. Representations for resources will also be defined, as will representations for capturing situation data. Task definitions will require examination and refinement of mission METLs to establish a standardized set of tasks, as is currently being done for some other Navy missions (e.g., EOD missions at NAVEODTECHDIV).

- 3.2 Populate plan decision library. This will contain a set of plan decomposition “cases” for refining tasks into subtasks, along with appropriate resource assignments.
- 3.3 Define retrieval and plan adaptation strategies. Cases will be conditioned by (possibly abstracted) situation data that will be used to rank stored planning decisions during the EDSS planning process. As the (human) planner identifies the task currently being decomposed, the PA module will provide a ranking of potential cases for decomposing that task, and the planner will have the option of examining and selecting one of these plan decomposition cases. PA will also provide adaptation suggestions for the stored cases that explain how they can be adapted for the current planning scenario.
- 3.4 Plan decision acquisition component. Plan decision cases will be captured from EDSS planners using a (probably off-line) process that analyzes task decompositions in a completed plan. Cases will be composed of the parent task, the set of decomposed subtasks, and the expected situation (at that time in the plan scenario) that can be used to index those cases.
- 3.5 Module development. Similar to Task 1.4.

Task 4: *Plan expertise sharing* (PE module). (FY03-04)

- 4.1 Define lesson representation. Drawing from our previous experience with lessons learned processes (Weber et al., 2001) and monitored lesson distribution (Weber & Aha, 2002), we plan to index lessons by *task* and situation data (i.e., retrieval *conditions*), and have them return *suggestions* concerning preferences for alternative task-decomposition decisions and associated *explanations*.
- 4.2 Lesson sharing component. PE will automatically bring lessons to the attention of users using a minimally obtrusive approach, whereupon the planner can decide whether to implement its suggestion.
- 4.3 Lesson capturing component. This tool will interactively guide the user in capturing reusable lessons in a similar approach to our Lesson Elicitation Tool (LET) (Sandhu & Aha, 2002).
- 4.4 Module development. Similar to Task 1.4.

Task 5: *EDSS integration*. (FY04) These critical tasks will be refined as EDSS 2.x is designed and implemented. We expect to define APIs for each of our modules to facilitate their integration.

WORK COMPLETED

Tasks 1.1-1.4 have been completed as of 9/02, with version 2.0 of the PD module having been completed. We are currently extending PD so that it can be used to detect additional constraint violations concerning deck management and related tasks.

RESULTS

During FY02, our first year on this project (2/02-9/02), it supported the PI at 25% and our software engineer at 50%, which is enough to familiarize ourselves with the ship-to-shore planning domain and develop initial versions of the Plan Deconfliction (PD) module (Figure 1). Thus, our most meaningful technical result was the development of PD, which included defining a representation for ship-to-shore planning constraints, the interpretation of EDSS time-stamped simulation data, the extraction of constraints from the subject matter expert, and their identification in the time-stamped data. We learned that these constraints, to date, have been relatively simple to represent, which may imply that we will have great flexibility in focusing on the AI reasoning aspects of our work during FY03-04.

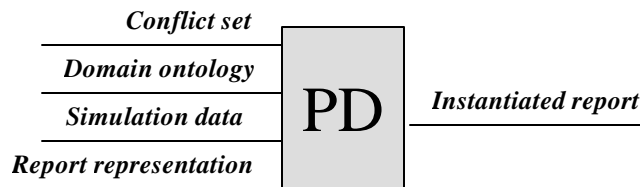


Figure 1: Abstract I/O of the Plan Deconflicter (PD) Module. [Inputs: conflict set, domain ontology, simulation data, and report representation. Output: the instantiated report.]

IMPACT/APPLICATIONS

Regarding scientific impact, our investigation of case-based approaches for dynamic planning (with our U.Maryland sub-contractors) and plan authoring will significantly extend the state-of-the-art due to the complexity of the simulator, which is a far more expressive test bed then the domains currently in vogue in academic work on AI planning. In particular, this is an excellent opportunity to extend our work on plan authoring and lessons learned processes into an end-to-end knowledge management capability that includes elicitation, indexing, retrieval, and dissemination activities. To our knowledge, no such capability has been published for a mission planning context.

The systems application impact of our work is the delivery of EDSS v2.x modules during FY04, when we can expect it will be first available for module integration and testing.

TRANSITIONS

The results of this project, started in February 2002, have not yet been transitioned. However, our focus is on transitioning all developed modules to a future version of EDSS. In particular, EDSS v2.x will be developed in Java (thus executable on stand-alone PCs), run on GCCS-M 4.x, and support distributed/collaborative planning. Our software development effort has been guided by the lead software engineer for EDSS (Shawn Faust) with the intention to simplify EDSS v2.x integration.

RELATED PROJECTS

ONR's Barry Blumenthal (Code 32CM) is funding a small set of closely related projects in support of EDSS. The primary project is the development of EDSS itself, which is being performed by SAIC (POC: C.Swanson). Our goal is to develop integratable modules for EDSS 2.x. Also related is the joint U.Washington (APL) and NRL project (PIs: R.Miyamoto, J.Ballas) that is performing a task analysis and interface design for EDSS 2.x. Our modules are being designed to accommodate this design. Finally, Daniel H. Wagner Associates (PI: R.Monach) is developing schedule optimization algorithms for EDSS to support Ship-to-Objective Maneuver (STOM). During FY03, we will extend our plan deconfliction module to detect constraint violations for ship deck management planning tasks.

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PUBLICATIONS: No submissions at this time; we expect this work to lead to publications late in FY03. Project documents are available at <http://www.aic.nrl.navy.mil/~aha/ida/projects/ONR/EDSS>.

PATENTS: None